Energy Harvesting, Storage and Management for Automated Environment Monitoring in the East African Region

PROGRESS REPORT – MARCH

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Problem

The comprehensive problem is:

Continual failure of AWS power systems deployed in East African Environments

Failure due to :

- Technical failure (worn-out batteries, leaking batteries due to heat)
- Human-induced failure such as vandalism to acquire solar panels
- Short-term failure: Batteries running down on short-time basis due to short energy supply due to poor sizing the energy harvesting unit (e.g solar panel)

Specific Problems

1. High Power Consumption

Many stations have advanced functions that are often unnecessary. e.g remote login

- Frequent Multiple charge-discharge cycles that lead to low battery life
- Large batteries and solar panels – these are costly and often vandalism

2. Sub-optimal energy harvesting

- No practical sizing data for Energy Harvesting Units for AWS or low power DC applications
- These can be solar or wind

3. Use of traditional battery technologies: Poor performance in outdoor deployments

- Traditional battery technologies (Lead-Acid, Li-ion and Ni-MH) are less-responsive to intermittent energy sources (sun/wind) compared to some emerging battery technologies (e.g. supercapacitors)
- Poor charge accumulation
- Large self-discharge

Specific objectives

To design a very low power data acquisition unit/gateway so *to obtain longer battery lifetime especially during autonomy periods and fewer charge-discharge cycles. Gateway functionality is: Receive, Timestamp, Store and Transmit. Basic functionality.*

To obtain evidence-based sizing data for energy harvesting units to be deployed with AWS in the region so as *to obtain the practical minimum unit sizes required to sustain a given continuous power consumption in typical environmental conditions.*

To evaluate the performance of emerging battery technologies at high environmental temperatures *to obtain the best suited for (hot regions in) the East African Region. Scope: charge accumulation rate and self-discharge of supercapacitors especially at high temperatures*

Motivation

In 2014-2015, one WIMEA surveys in Uganda and one in Tanzania revealed wide spread failure of automatic weather stations in Uganda. Failure of one or several components of the power system was a major cause.

In October 2014, 11 of 37 (30%) of stations across Uganda had failed due to power-related issues e.g vandalized solar panels, leakage due to batteries, worn-out batteries

It is from these surveys it was realized that there is need to improve the reliability of AWS power systems in EA.

Administrative Progress

- Doctoral Committee presentation happened successfully on March 1

Advice:

1. The contribution of Objective 3 needs to be clearer. **Objective 3: Self-discharge of LICs at high environmental temperatures.** Question was: What are there observed challenges with batteries deployed outdoors in other countries that have difficult conditions. See if you can get more data. **QN: Is it not enough that it is a proof of concept on this new technology?**
2. Specific objectives should be increased to 4. The fourth should be a system integration to demonstrate how a proposed design incorporating objectives 1-3 performs.
3. Methodology should be expressed in MUK-standard format (with Conceptual Framework etc)
4. Revise proposal, prepare minutes and re-submit such that HDRC can be scheduled

Progress Low Power gateway

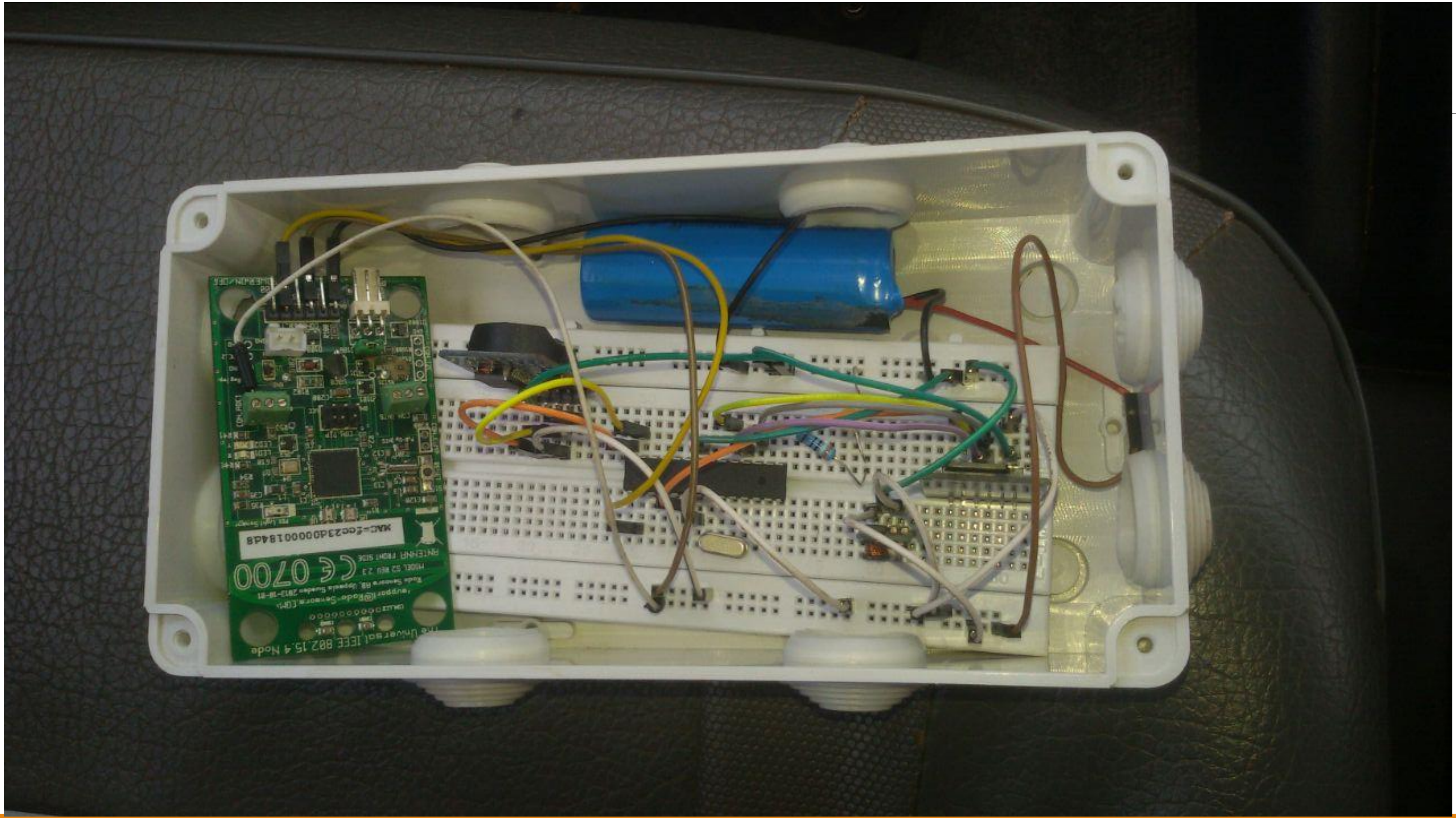
Current design:

RS2 Mote + Raspberry Pi

15mA + 1300mW

Time Stamping,
Persistent Storage

Low Power Gateway - Progress



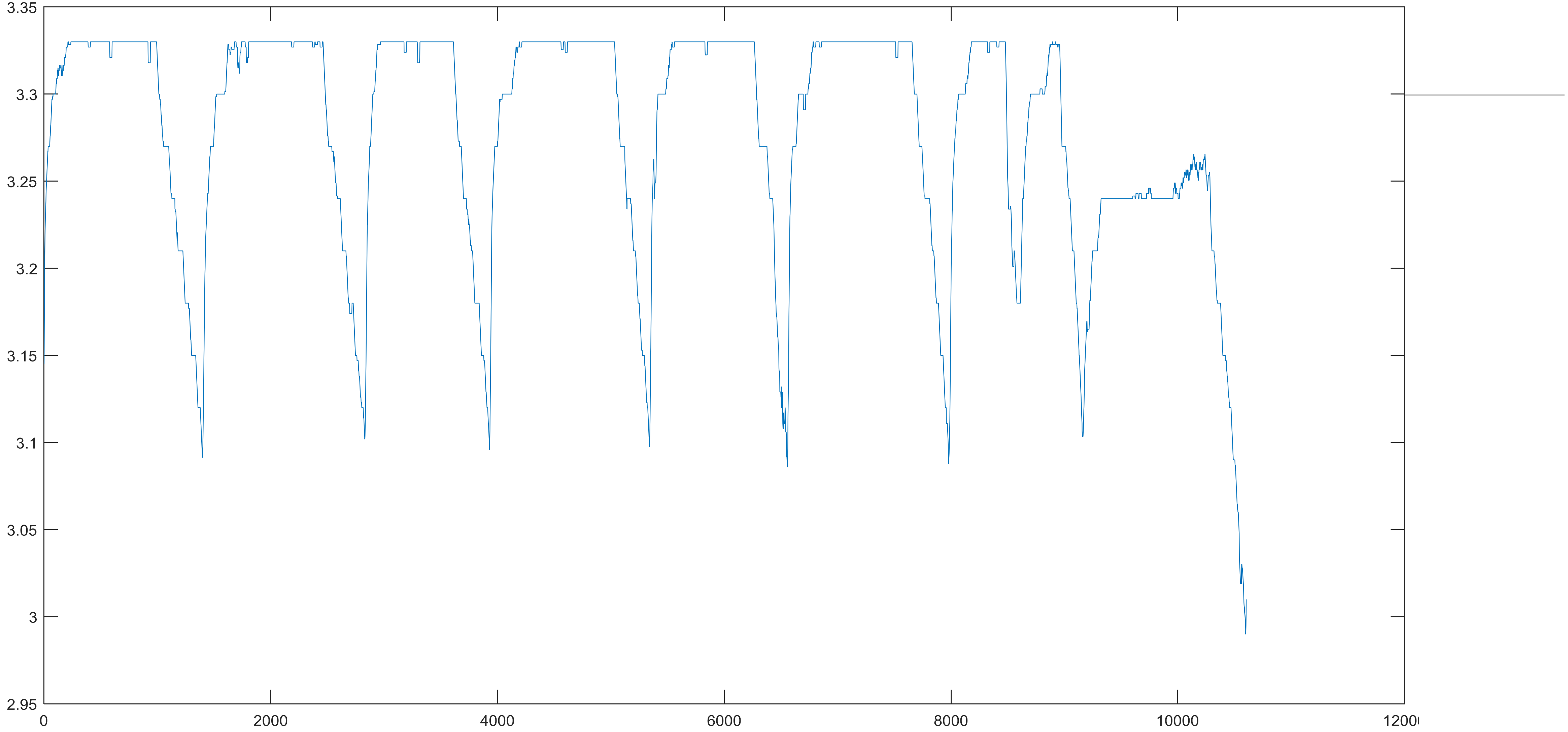
Progress – Low Power gateway

- SD card functionality was a **major breakthrough**. We now have Receive + RTC + SD card on 1 device.
- 2 Design philosophies
  - **Alternative 1** – functional since 9th March. Over 67,000 reports on battery charge status. Consumption is 12mA (down from 35mA) WIMEA-ready.

  Pros: Easy Development (uses OOP- Arduino) . RAD.

  Cons: Sleep mode Misses consecutive reports. We have to sacrifice 25% of power. (else, ~9mA)
  - **Alternative 2** – Receive, Timestamp, buffer in RAM, send to uplink. In development. Drivers being developed. Uses Contiki OS.
  - Pros: No report miss in sleep mode.
  - Cons: Uses pure C. More development time. Drivers need to be written for new peripherals like RTC and SD card.
  - RTC has been written.

Some Analysis



Justification for objective 2

Evidence based solar sizing.

Average on-time is 14 hrs

21-03	04:51-19:10	15
22-03	04:44 – 16:24	12
25-03	04:56 – 18:22	16

5W panel is giving 58% availability at this time of year.

Consumption is 12mA x 3.15V = 38mW (912 mWh per day ~ 182mW panel for 5 hrs sunshine)

5W is 27 times greater. We need data-based sizing

Progress on other objectives

Objective 3: Self-discharge of LICs at high environmental temperatures

Test bed set-up finished on Monday. Experiment starts today. Environment temperatures being generated in controlled environment using dimmable incandescent bulb. Data collection is automated. Experiment to last 1000 hours.

April Plans

- ❑ Finish Contiki-based gateway (Alternative 1)
- ❑ Finish Paper ***Practical Design Guidelines for Ultra-low Power Gateways in Environment Monitoring Wireless Sensor Networks***
- ❑ Finish proposal and present to HDRC
- ❑ Get linux-based uplink up and running
- ❑ Get the RC3 student matriculated into the project